

Dark Matter and Supersolidity

Sisir Roy & Malabika Roy

Physics & Applied Mathematics Unit

Indian Statistical Institute

Calcutta-700 035, India

e-mail : sisir@isical.ac.in

Abstract

The recent experiments on supersolidity shed new light on the issue of Dark matter and the missing mass. The origin of collisionless cold dark matter has been traced back to its origin to the supersolid model of quantum vacuum.

1 Introduction

The issue of Dark matter raised lot of controversy over the past decade. The universe is supposed to be full of "dark matter" that influences the evolution of the universe gravitationally but not observed directly. The Cambridge team put a limit on how it is packed in space. Their observations claimed that this dark matter makes 85 percent of the universe. Very recently, the European space agency found the possible distribution of the dark matter in the universe. Dark matter are divided into two broad groups

1. Hot Dark matter(HDM)
2. Cold dark matter(CDM)

Particles of zero or near-zero mass are main constituents of Hot Dark matter while Cold Dark Matter are mainly composed of massive particles moving at sub-relativistic velocities. The HDM plays different role than CDM in structure formation because the high velocities of HDM wipes out the structure at small scale. The recent experiments^{1,2} at low temperature indicates a new state of matter popularly known as supersolid. Any individual wave-packet associated with a single atom increases in size as it is being cooled especially around absolute zero where as at higher temperature atoms are locked in a grid. Thus atoms lose their individuality at very low temperature and become one giant atom. The results attracted lot of attention because the characteristics of solid and liquid is describable only within the weird world of quantum mechanics. It is well known that a solid can not flow so it can not exhibit some of the properties of liquid like superfluid. However, when the above superfluid is put under pressure slightly above absolute zero, a portion of it becomes supersolid and loses its friction completely. Here, the crystal suddenly became lighter but the missing mass reappeared when it is slightly heated. Several authors³ pointed out that the vacuum can be thought of as type of superfluid and others considered it as with little resistance or non-zero conductivity^{4,5}. They tried to explain redshift using the concept of tired light. Here, we propose that the vacuum is composed of supersolid like matter which can be thought of as collisionless cold dark matter. This sheds new light on the origin of missing mass. We shall discuss the dark

matter and the issue of missing mass in section II. Possible implications are discussed in section III.

2 Hot and Cold Dark Matter

Astronomer Zwicky^{6,7} coined the term Dark Matter. In 1933 during his measurement of individual velocities of a large group of galaxies, the galaxies are found to be moving with so rapidly that they should come apart. The visible mass of the galaxies in the cluster can not produce enough gravitational force to confine the galaxies within the cluster. He speculated perhaps the missing mass do not give off or reflect enough light to see them. The cosmologists working with Big Bang hypothesis faced an entirely different problem. They found that there is not enough gravitational energy in the cosmos so as to be compatible with General Theory of Relativity. They called it as Dark energy. If one believes that gravitational force is the only force in the cosmos, then ⁸ of the universe had to be filled with missing entities. Dark matter are broadly classified into two groups: Hot Dark Matter and Cold Dark Matter. The fast moving particles like neutrinos, tachyons are supposed to be constituent of HDM and massive particles are for CDM. Ostreiker and Steinhardt⁹ made a list for several types of dark matter:

1. Cold Collisionless Dark Matter (CCDM)
2. Strongly Self interacting Dark Matter
3. Warm Dark Matter
4. Repulsive Dark Matter
5. Self annihilating dark matter
6. Fuzzy dark matter

The predictions of cold dark matter have been analyzed with respect to the present observational evidences. Moreover, it is not at all clear about the nature of cold dark matter particles. Lambda-Cold Dark Matter has also been discussed as a concordance model

of big bang cosmology. However, it says nothing about the physical origin of dark matter. Here, we consider the quantum vacuum as consisting of supersolid like matter. Chan and Kim² observed that when a particular isotope of helium gas has frozen into a crystal at a fraction of a degree above absolute zero, part of it exhibits a property with no friction as observed in superfluids. It seems some mass is missing and by reheating it increases the resistance and mass reappears. This fluid is frictionless ie. like collisionless matter not observed directly. So the primordial supersolid is like collisionless dark matter. It is possible to trace back to the physical origin of this type of cold dark matter.

3 Possible Implications

The above analysis sheds light on the physical origin as well as the possibility of observing dark matter. Moreover, the distribution of dark matter can be studied within this framework.

4 References

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